

Economic Analysis of Integrated On-Farm Drainage Management

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Chapter 8. Economic Analysis of Integrated On-Farm Drainage Management

A. Introduction

The goal of integrated on-farm drainage management is to eliminate the need for discharging subsurface drainage water from a farm to surface water. This is accomplished by improving irrigation practices to reduce deep percolation and by collecting and evaporating subsurface drainage water through plants or in a solar evaporator constructed on the farm. The size of the solar evaporator is a function of irrigation management practices, the volume of drainage water collected and the evaporation rate. Farmers can minimize the area required for the evaporator by implementing irrigation practices that reduce deep percolation and the volume of water collected in subsurface drains.

Improving water management practices and installing subsurface drains will increase the cost of farming, while generating benefits that might include higher yields and long-term improvements in soil quality. The cost of irrigation water can be reduced if farmers purchase or pump less water after improving their water management practices. The benefits will vary substantially among farms, according to differences in crop production choices, agronomic practices, and the initial quality of soil and water resources. The component costs of implementing IFDM will be somewhat similar among farms, but the total cost will vary with differences in the size of the solar evaporator and the amount of land used to produce non-marketable, salt-tolerant crops.

The primary goal of this chapter is to describe the costs of implementing IFDM. A partial-budget analysis of cost implications is presented, rather than addressing all aspects of farm-level costs and returns. The framework described will enable farmers and their advisors to evaluate the potential financial implications of implementing IFDM. Farm-specific information regarding cost components, total costs and expected benefits can be analyzed using this framework. In some cases, IFDM will appear to be financially viable, while in others it might increase the net cost of farming. In all cases, farmers should think broadly regarding the full range of incremental costs and benefits they might attribute to implementing IFDM, both in the near term and over time.

The largest components of the cost of implementing IFDM are the costs of installing a subsurface drainage system (if a system is not already installed), the cost of installing a solar evaporator, and the cost of producing non-marketable, salt-tolerant crops, forages or halophytes. The opportunity cost of land used for the solar evaporator and the land used for producing non-marketable crops also must be considered. In some farm operations, these costs will be substantial. Farmers can minimize the total cost of implementing IFDM by reducing drainage water volume to minimize the size of the solar evaporator required, and by minimizing the area required for producing non-marketable crops.

The partial-budget analysis presented here is conservative, focusing on cost components without emphasizing potential benefits. As noted above, the cost components will be somewhat similar among farms, while benefits will vary with key assumptions regarding crop yields and prices. The goal is to present an objective analysis of the cost components without imposing a positive or negative view regarding the financial viability of IFDM. Farmers and their advisors will have better information available to evaluate farm-specific costs and returns. The empirical analysis demonstrates the methodology for considering all pertinent costs and benefits. Farmers and their advisors can use this framework and the spreadsheet in Appendix 8 (pages A-58 to A-63) and on the Appendix CD to examine farm-specific costs and benefits. In addition, they can conduct sensitivity analysis by varying assumptions regarding potential costs and benefits and examining the net financial impact of implementing IFDM.

B. Components of an IFDM System

A typical IFDM system includes three or four of the following components: 1) production of primary crops for sale in agricultural markets, 2) production of salt-tolerant plants (salt-tolerant crops, forages, and halophytes), 3) a subsurface drainage system, and 4) a solar evaporator. Drainage water generated by irrigating

the marketable crops can be used to irrigate the salt-tolerant plants, or it can be discharged directly to the solar evaporator. Using drainage water to irrigate salt-tolerant plants will reduce the volume of drainage water requiring evaporation, but the land allocated to those crops might generate little or no income in some years, depending on crop selection. Farm-level net revenue will be higher when farmers can produce higher valued, marketable crops on all of their irrigated land, while discharging the subsurface drainage water directly to the solar evaporator.

All four components of the typical IFDM system are considered in the empirical analysis that follows. Some farmers will choose not to include salt-tolerant crops, forages, and halophytes, so they can maximize the area planted in marketable crops. The framework will enable farmers to evaluate the economic implications of that strategy and of alternative system designs. Farmers can reduce or eliminate the area required for low-value, salt-tolerant plants by improving irrigation practices and reducing deep percolation. The farm-level costs of making those improvements can be compared with the potential reduction in the cost of an IFDM system, made possible by reducing or eliminating production of the most salt-tolerant plants.

C. Conceptual Framework

In this analysis, the entire cost burden of the IFDM system, including the fixed and variable costs of the subsurface drainage system, the solar evaporator and the production of any low value salt-tolerant plants, is placed on the land used to produce marketable crops. As a result, the average cost of the IFDM system (per acre of marketable crops) rises with the proportion of the irrigated area used to produce low-value, salt-tolerant plants. In some years, farmers might receive revenue from the sale of salt-tolerant crops and forages, but that source of revenue is not included in this analysis. If land is allocated to salt-tolerant plants with little economic value, the opportunity cost of that land and any variable costs of production must be recovered from production of marketable crops on the remaining land area.

The annual fixed costs of the IFDM system include the amortized costs of the subsurface drainage system and the solar evaporator. The rental or opportunity cost of land used for the evaporator and for production of non-marketable, salt-tolerant plants also is included in the annual fixed costs. The initial cost of the subsurface drainage system includes engineering analysis, design, and construction. The initial cost of the solar evaporator also includes engineering analysis and construction, and the costs of the pipes, pumps, and sprinklers needed to distribute the drainage water. The rental rate or opportunity cost of land is included in the fixed cost of the solar evaporator. That cost also is included for any land allocated to the production of low-value, salt-tolerant plants.

The variable costs of an IFDM system include the operation and maintenance of the subsurface drains and the solar evaporator. Included also is the cost of an IFDM system manager, who monitors operation of the subsurface drainage system and the solar evaporator. The manager also supervises the production and irrigation of any low-value, salt-tolerant plants. The costs of producing low-value, salt-tolerant crops and forages are included in the variable costs of the IFDM system for scenarios that include production of those crops.

The annual benefits or returns to the IFDM system include the incremental production values made possible by providing subsurface drainage, and the avoided cost of disposing drainage water in some other, more costly, manner. Those benefits are not estimated in this analysis. However, the benefits can be substantial in arid regions where subsurface drainage systems are required to maintain productivity, and where public agencies regulate the discharge of agricultural drainage water into streams and other waterbodies. Benefits also might be large where IFDM systems enable farmers to maintain or improve soil productivity, while minimizing the re-use of saline drainage water on land used for primary crops. Those enhancements will enable some farmers to increase their annual revenues by replacing low-valued grains and forages with higher valued, salt-sensitive crops, such as fruits and vegetables on some of their land.

As described above, only the costs of installing and operating an IFDM system are considered. Other costs of crop production are not considered. This is a partial-budget analysis of the decision to install an IFDM system by a farmer seeking to provide drainage service and to dispose the collected drainage water within his or her farming operation. The goal is to present a framework farmers can use to evaluate their options

regarding installation of an IFDM system. The farm-level costs of an IFDM system are described for a range of assumptions regarding the size of the solar evaporator and the proportion of irrigated land used to produce low-value, salt-tolerant plants. The estimated costs used can be replaced by precise values that describe actual costs for individual farming operations when those data are available.

D. Empirical Analysis

Key components of the partial-budget analysis include the following: 1) the estimated costs of installing, operating and maintaining the subsurface drainage system and the solar evaporator, 2) the proportions of land area required for the solar evaporator and for production of salt-tolerant plants, 3) the opportunity costs, taxes, and assessments on land used for the evaporator and for production of low-value, salt-tolerant plants, and 4) the interest rate and length of time used to amortize the initial costs of the drainage system and the solar evaporator. The estimated average cost of the IFDM system will increase with the proportion of land allocated to salt-tolerant plants and the size of the solar evaporator, and with the rental rate or opportunity cost of land. The average fixed cost will be smaller for lower interest rates and for longer periods of amortization.

A 640-acre farm is used in this empirical analysis, assuming that 600 acres of the farm are served by a subsurface drainage system. Irrigated production of marketable crops and salt-tolerant plants occurs on those 600 acres, while the solar evaporator is constructed somewhere within the remaining 40 acres. The sizes of the solar evaporator were assumed to range from 0.5% to 2% of the irrigated area, or from 3-to-12 acres. The proportions of irrigated area planted in non-marketable crops in this analysis include zero, 10% and 20% for low-valued, salt-tolerant crops and forages, and zero, 1%, 2%, and 4% for halophytes. Hence, the area planted in marketable crops ranges from all 600 irrigated acres if no land is allocated to salt-tolerant plants, to 456 acres if 120 acres are planted in low-value, salt-tolerant crops and forages, and 24 acres are planted in halophytes.

The estimated cost of installing a subsurface drainage system on 600 acres of land is \$240,000, or \$400 per acre. The actual cost will vary among farms with differences in drainage conditions and land characteristics, and the availability of government programs that reimburse a portion of the costs. The assumed cost of installing a simple solar evaporator is \$1,000 per acre of land used for the evaporator. The initial costs of the drainage system and the evaporator are amortized over 20 years and 10 years, respectively, using an interest rate of 6.25%, which is the ten-year average rate of return to production assets from current income in California agriculture (Hutmacher et al., 2003). The amortized costs are \$36 per acre of irrigated land for the drainage system and \$137 per acre of land used for the solar evaporator (Table 1). The estimated annual costs of operation and maintenance for the drainage system and solar evaporator are \$5 and \$120 per acre, respectively.

The estimated rental rate or opportunity cost of land is \$150 per acre, and the estimated sum of annual taxes and assessments on the land is \$25 per acre. These costs are added to the annual cost of land used for the solar evaporator and for producing low-value, salt-tolerant plants. Hence, the estimated annual cost of owning and operating the solar evaporator is \$432 per acre of land used for the evaporator (Table 1).

The annual fixed cost of producing salt-tolerant plants includes the sum of annual taxes and assessments on the land and the rental or opportunity cost. The variable costs include the labor, fertilizer, pesticides and other inputs required to maintain the plants. The fertilizer and pesticide requirements will be smaller for low-value, salt-tolerant plants than for primary crops for two reasons: 1) the salt-tolerant plants will be irrigated with drainage water that contains some of the nutrients required to support plant growth, and 2) the salt-tolerant plants likely will attract fewer pests that need to be suppressed using pesticides. Farmers will use larger amounts of chemical fertilizers and other inputs in years when they plan to sell their salt-tolerant crops and forages. Input use will be minimal in years when the crops are grown only for the purpose of disposing of subsurface drainage water.

An estimate of \$339 per acre is used for the annual production cost for low-value, salt-tolerant crops and forages, which is the estimated operating cost for producing winter forage in the San Joaquin Valley (Campbell-Mathews et al., 1999). Hence, the sum of the annual costs for land planted in salt-tolerant crops and forages is \$514 per acre (Table 1). The estimated annual production costs for halophytes are only \$25 per acre, given that

those crops will not be produced for sale. The sum of the estimated annual costs for land planted in halophytes is \$200 per acre (Table 1).

In some years, salt-tolerant crops and forages might be sold for a price that equals or exceeds the cost of production, but in most years, the net returns from that activity likely will be negative. Given this conservative approach, any revenue from low-value, salt-tolerant crops, forages or halophytes is not considered. However, farmers and their advisors can include such estimates when evaluating farm-specific financial implications of implementing IFDM. In general, it will be desirable for farmers to minimize drainage water volume by improving irrigation practices, and to use all of their irrigated land for production of higher valued crops. Farmers planning to produce salt-tolerant plants for sale can consider their expected revenues when estimating the likely costs and returns of investing in an IFDM system.

As noted above, the optimal size of a solar evaporator will vary with the volume of drainage water requiring disposal and with the local evaporation rate. The area of land allocated to production of low-value, salt-tolerant plants also will vary among farmers, according to their preferences regarding crop production and marketing alternatives, and with their ability and desire to reduce drainage water volume through improvements in irrigation water management. To reflect this potential variability, a range of proportions for the land area allocated to low-value, salt-tolerant plants and the solar evaporator is examined. The size of the solar evaporator ranges from 0.5% to 2.0% of the irrigated area, or from 3 to 12 acres. Three proportions of land area in low-value, salt-tolerant crops or forages (zero, 10%, and 20%) are considered, and the proportion of area planted in halophytes ranges from zero to 4%.

Three scenarios pertaining to the three proportions of land in salt-tolerant forages are described in Tables 2 through 7. The net areas of irrigated land used to produce higher valued, marketable crops are shown in Table 2, for the ranges of assumed values regarding the areas allocated to producing halophytes and salt-tolerant crops and forages. The estimated total, annual costs of owning, operating, and maintaining the solar evaporator and allocating land for the production of salt-tolerant plants are shown in Table 3. The estimated annual cost for the 640-acre farm ranges from \$1,297 to \$5,190 if no land is used to produce salt-tolerant plants and from \$67,777 to \$71,670 if 20% of the irrigated land is used to produce low-value, salt-tolerant crops or forages and 4% of the irrigated land is used to produce halophytes. The annual cost rises substantially with the proportion of land allocated to the production of low-value, salt-tolerant crops or forages, given the estimated annual cost of \$514 per acre for that activity (Table 1).

The estimated annual costs presented in (Table 3) are divided by the net areas used to produce higher valued crops (Table 2) to determine the estimated average cost per acre imposed on production of the higher valued crops. Those estimates range from \$2 to \$9 per acre if no land is used to produce low-value, salt-tolerant plants, and from \$149 to \$157 per acre if 20% of the irrigated land is used to produce salt-tolerant crops or forages and 4% of the irrigated land is used to produce halophytes (Table 4). These cost estimates will be helpful for farmers who already have installed a subsurface drainage system, but are seeking an alternative method for disposing the collected drainage water. Those farmers will need only to: 1) install and operate the solar evaporator, 2) decide how much land, if any, to allocate to the production of low-value, salt-tolerant plants, and 3) hire an IFDM system manager to monitor and operate the system. The estimated costs in Table 4 pertain to the first two components of that decision.

The estimated annual costs of an IFDM system manager, per acre of irrigated land used to produce higher valued, marketable crops are shown in Table 5. Those costs, which pertain to an annual salary of \$35,000, range from \$58 per acre if no land is used to produce low-value, salt-tolerant plants to \$77 per acre if 20% of the irrigated land is used to produce low-value, salt-tolerant crops or forages and 4% of the irrigated land is used to produce halophytes. Hence, the incremental annual cost of implementing an IFDM strategy for farmers who already have a subsurface drainage system will range from \$60 (\$58 + \$2) to \$234 (\$77 + \$157) per acre of irrigated land used to produce marketable crops. Estimates pertaining to specific assumptions regarding the size of the evaporator and the area used to produce salt-tolerant plants can be obtained by summing the pertinent cost estimates in Tables 4 and 5.

The estimated annual cost of owning, operating, and maintaining the subsurface drainage system is \$40.58 per acre (Table 1). The average cost, per acre of marketable crops, increases with the proportion of irrigated

land allocated to low-value, salt-tolerant plants. The average cost ranges from \$41 per acre if no land is used to produce low-value, salt tolerant plants, to \$53 per acre if 20% of the irrigated land is used to produce salt-tolerant crops or forages and 4% of the land is used to produce halophytes (Table 6).

The estimated annual cost of all components of the IFDM system is determined by summing the pertinent cost estimates in Tables 4, 5, and 6. The summary cost estimates range from \$101 to \$108 per acre of irrigated land used to produce higher valued, marketable crops if no land is used to produce salt-tolerant plants, and from \$279 to \$287 per acre if 20% of the irrigated land is used to produce salt-tolerant crops or forages and 4% of the irrigated land is used to produce halophytes (Table 7). All of the cost estimates appearing in Table 7 are between \$100 and \$300 per acre of irrigated land used to produce marketable crops.

E. Discussion

The estimated average cost of owning, operating, and maintaining an IFDM system increases substantially with the proportion of irrigated land allocated to the production of low-value, salt-tolerant plants. The cost estimates for Scenario B, in which 10% of the irrigated land is used to produce low-value, salt-tolerant crops or forages, are about 65% higher than those for Scenario A, in which no land is used for that activity (Table 7). The cost estimates for Scenario C, in which 20% of the irrigated land is used to produce low-value, salt-tolerant crops or forages, are more than double those for Scenario A. These results describe one component of the farm-level economic incentive to improve water management and reduce drainage water volume. The costs of collecting, managing, and disposing drainage water can be reduced substantially if only a small area is required for producing alternative crops. In addition, the revenue received from sales will be higher when a larger proportion of the irrigated land is used for producing primary, higher valued crops.

The incremental costs of improving irrigation water management can be evaluated in comparison with the incremental benefits of reducing the average cost of implementing the IFDM strategy. For example, successful efforts to reduce the area required for low-value, salt-tolerant crops or forages from 20% to 10% of the irrigated area will reduce the average annual cost of the IFDM system by about \$90 per acre of land used to produce higher valued crops (Table 7). Eliminating the area allocated to salt-tolerant plants will reduce that cost by an additional \$70 per acre.

The cost of an IFDM system can be reduced also by utilizing land that has a smaller rental rate or opportunity cost for the solar evaporator and for production of salt-tolerant plants. Some land in drainage problem areas might already be impacted by a saline high water table and its rental rate or opportunity cost will be smaller than that of other land in the region. If drainage-impacted land is used for the solar evaporator and for production of low-value, salt-tolerant forages and halophytes, the average cost of the IFDM system will be reduced. For example, the estimated average cost declines from \$108 to \$106 per acre when the land cost decreases from \$150 to \$50 per acre, when 2% of the land is allocated to the solar evaporator and no land is used for producing salt-tolerant plants (Table 8). More notably, the average cost declines from \$287 to \$253 per acre when the rental rate or opportunity cost declines from \$150 to \$50 per acre, when 2% of the land is allocated to solar evaporator, 20% of the land is used to produce low-value, salt-tolerant crops or forages, and 4% of the land is used to produce halophytes.

The estimated average costs of installing and operating an IFDM system are relatively high, when compared with the potential net returns from some of the field crops produced in the San Joaquin Valley. For reasonable values of crop yields and prices, the estimated net returns above cash costs for alfalfa hay, cotton and tomatoes for processing are \$401, \$166 and \$498, respectively (Table 9). The estimated net returns above all costs are \$1, \$62 and \$402 per acre for those crops, respectively. The estimated average annual cost of an IFDM system in which 10% of the irrigated land is used to produce salt-tolerant crops and forages, 1% of the land is used to produce halophytes, and the size of the solar evaporator is 1% the size of the irrigated area, is \$176 per acre (Table 8). That cost would generate negative net returns in the production of alfalfa or cotton, while reducing the annual net returns in tomato production from \$402 per acre to \$226 per acre.

Cash costs generally include annual operating expenses and the taxes and assessments on land. Non-cash costs include the amortized costs of durable equipment, such as a solar evaporator and a subsurface drainage system. The cash and non-cash components of the estimated annual cost of a selected IFDM system are

presented in Table 10. The largest cash cost components are the salary for the IFDM system manager (\$65.54 per acre) and the costs of production for salt-tolerant crops and forages (\$38.09 per acre). The largest non-cash components are the amortized cost of the subsurface drainage system (\$39.98 per acre) and the rental or opportunity cost of land used for producing low-value, salt-tolerant crops and forages (\$16.85 per acre). The total cash operating cost for the selected IFDM system is \$110.88 per acre, while the sum of the non-cash operating costs is \$3.37 per acre. The sum of non-cash overhead expenses is \$61.75 per acre. Those sums appear also in the bottom half of Table 9.

The estimated total cash cost for the IFDM system (\$114.25 per acre) is about twice as large as the non-cash overhead cost (\$61.75 per acre). Hence, the installation of an IFDM system will have uneven impacts on the cash and non-cash components of crop production costs and the associated measures of net returns. For example, the installation of the selected IFDM system will increase the total cash cost of producing alfalfa from \$571 to \$685 per acre, or by about 20% (Table 9). The non-cash overhead cost of producing alfalfa will increase from \$400 to \$462 per acre (15.5%). The estimated net returns above operating costs will decline from \$478 to \$367 per acre (23.2%), while the estimated net returns above cash costs will decline from \$401 to \$287 per acre (28.4%). The estimated net returns above all costs will decline from \$1 to -\$175 per acre. Similar calculations can be obtained for other crops using the information in Table 9.

Farmers and their advisors can use the framework described in this section to evaluate the farm-specific implications of implementing IFDM. Alternative values describing key components of the costs and benefits of IFDM can be entered in the spreadsheet tables provided in Appendix 8 (pages A-58 to A-63) and on the Appendix CD. The net financial implications for some farmers will be more attractive than the results pertaining to the example.

F. Conclusions

The average cost of installing, maintaining and operating an IFDM system, per acre of land used to produce marketable crops, increases substantially with the proportion of land area allocated to the solar evaporator and to production of low-value, salt-tolerant plants for this example. If only 0.5% of the area is required for the solar evaporator and all of the irrigated land is used to produce marketable crops, the estimated average annual cost is \$101 per acre, for rental rates ranging from \$50 to \$150 per acre (Table 8). The average annual cost ranges from \$158 to \$177 per acre of land in marketable crops when 10% of the irrigated land is used to produce low-value, salt-tolerant crops or forages. If 20% of the irrigated land is used to produce low-value, salt-tolerant crops or forages, the estimated annual cost ranges from \$247 to \$287 per acre.

The estimated average annual cost of installing and operating an IFDM system is substantial, in comparison with the estimated costs of production and net returns for some of the field crops grown in the San Joaquin Valley. The estimated net returns above total costs become negative for alfalfa and cotton when adjusted for the average cost of an IFDM system. The estimated net returns above total costs remain positive for processing tomatoes, although they are reduced by about 44%. All of these estimates pertain to one configuration of an IFDM system and the values assumed. The estimated impacts on crop production costs and net returns will be different for other configurations and cost estimates.

Farmers can reduce the average cost of implementing IFDM by improving irrigation water management and by choosing land parcels with small rental rates or low opportunity costs. In some cases, farm-level improvements in water management will generate higher costs of production that will offset a portion of the reduction in the cost of implementing IFDM. However, annual net revenue might increase with reductions in water deliveries and improvements in crop yields. Farmers also might generate revenue by selling low-value, salt-tolerant forages and other crops in some years. **A complete evaluation of farm-level IFDM strategies will include analysis of these additional, potential sources of costs and revenues.**

The economic implications of implementing IFDM will be more favorable for farmers who already have installed a subsurface drainage system, and who seek a method for disposing the collected drainage water within their farming operation. Those farmers might need to modify their existing drainage system by inserting flow control structures or installing new pumps and pipes to carry drainage water to a solar evaporator, but they will not need to invest in a completely new drainage system. If those farmers can reduce

drainage water volume sufficiently to avoid the need for including salt-tolerant plants in their IFDM system, the incremental cost of implementing that strategy will be about \$70 per acre of land used to produce marketable crops. That estimate is determined by subtracting \$36 per acre for the drainage system investment cost from the cost estimates that appear in the first column of Table 7. A further reduction in cost can be achieved if the system can be managed by a part-time staff person, rather than a full-time manager. That adjustment might be possible if the volume of drainage water collected each year is small enough that the IFDM strategy can be implemented successfully without the irrigation of low-value, salt-tolerant plants.

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Table 8-1.

The estimated costs of Installing, operating, and maintaining the solar evaporator and the estimated annual costs of land used for the evaporator, salt-tolerant crops, forages, and halophytes

Item	Initial Cost (\$/acre)	Annual Costs (\$/acre)
The Subsurface Drainage System		
Estimated installation cost	400.00	
Amortized installation cost		35.58
Operation and Maintenance		5.00
Sum of Estimated Annual Costs for the Drainage System		40.58
The Solar Evaporator		
	(\$/acre)	(\$/acre)
Estimated installation cost	1,000.00	
Amortized installation cost		137.48
Operation and maintenance		120.00
Taxes and assessments		25.00
Rental or opportunity cost		150.00
Sum of Estimated Annual Costs for the Evaporator		432.48
Land Used for Salt-tolerant Crops and Forages		
		(\$/acre)
Taxes and assessments		25.00
Rental or opportunity cost		150.00
Annual production costs		339.00
Sum of Estimated Annual Costs for Salt-tolerant Crops		514.00
Land Used for Halophytes		
		(\$/acre)
Taxes and assessments		25.00
Rental or opportunity cost		150.00
Annual production costs		25.00
Sum of Estimated Annual Costs for Halophytes		200.00

Table 8-2.

The net area of land in production of higher valued crops, for different assumptions regarding the size of the solar evaporator and the proportion of of area planted in salt-tolerant crops, forages, and halophytes

Proportion of Area in Halophytes (%)	Scenario A	Scenario B (acres)	Scenario C
0	600	540	480
1	594	534	474
2	588	528	468
4	576	516	456
Notes:			
Scenario A:	No Salt-Tolerant Crops or Forages		
Scenario B:	10% of Land in Salt-Tolerant Crops or Forages		
Scenario C:	20% of Land in Salt-Tolerant Crops or Forages		

Table 8-3. The estimated total, annual cost of owning, operating, and maintaining a solar evaporator and using land to produce salt-tolerant crops, forages, and halophytes

The Solar Evaporator		Scenario A No Salt-Tolerant Crops or Forages				Scenario B: 10% of Land in Salt-Tolerant Crops or Forages				Scenario C: 20% of Land in Salt-Tolerant Crops or Forages			
Proportion of Area	Number of Acres	Proportion of Area in Halophytes (%)				Proportion of Area in Halophytes (%)				Proportion of Area in Halophytes (%)			
		0	1	2	4	0	1	2	4	0	1	2	4
(% of area)	(acres)	(\$/year)				(\$/year)				(\$/year)			
0.5	3	1,297	2,497	3,697	6,097	32,137	33,337	34,537	36,937	62,977	64,177	65,377	67,777
1.0	6	2,595	3,795	4,995	7,395	33,435	34,635	35,835	38,235	64,275	65,475	66,675	69,075
1.5	9	3,892	5,092	6,292	8,692	34,732	35,932	37,132	39,532	65,572	66,772	67,972	70,372
2.0	12	5,190	6,390	7,590	9,990	36,030	37,230	38,430	40,830	66,870	68,070	69,270	71,670
Assumptions used in creating this table													
The irrigated, agricultural area considered in this example is:						600 acres.							
The proportions of irrigated area in salt-tolerant forages are:						Scenario A:		0 percent.					
						Scenario B:		10 percent.					
						Scenario C:		20 percent.					

Table 8-4. The estimated annual cost of owning, operating, and maintaining a solar evaporator and using land to produce salt-tolerant crops, forages, and halophytes, per acre of irrigated land

The Solar Evaporator		Scenario A No Salt-Tolerant Crops or Forages				Scenario B: 10% of Land in Salt-Tolerant Crops or Forages				Scenario C: 20% of Land in Salt-Tolerant Crops or Forages			
Proportion of Area	Number of Acres	Proportion of Area in Halophytes (%)				Proportion of Area in Halophytes (%)				Proportion of Area in Halophytes (%)			
		0	1	2	4	0	1	2	4	0	1	2	4
(% of area)	(acres)	(\$/acre)				(\$/acre)				(\$/acre)			
0.5	3	2	4	6	11	60	62	65	72	131	135	140	149
1.0	6	4	6	8	13	62	65	68	74	134	138	142	151
1.5	9	6	9	11	15	64	67	70	77	137	141	145	154
2.0	12	9	11	13	17	67	70	73	79	139	144	148	157
Assumptions used in creating this table													
The irrigated, agricultural area considered in this example is:						600 acres.							
The proportions of irrigated area in salt-tolerant forages are:						Scenario A:		0 percent.					
						Scenario B:		10 percent.					
						Scenario C:		20 percent.					

Table 8-5.

The estimated annual cost of an IFDM system manager,
per acre of irrigated land used to produce marketable crops

Proportion of Area in Halophytes (%)	Scenario A	Scenario B	Scenario C
		(\$/acre)	
0	58	65	73
1	59	66	74
2	60	66	75
4	61	68	77
Notes:			
Scenario A:	No Salt-Tolerant Crops or Forages		
Scenario B:	10% of Land in Salt-Tolerant Crops or Forages		
Scenario C:	20% of Land in Salt-Tolerant Crops or Forages		

Table 8-6.

The estimated annual cost of owning, operating, and maintaining a
subsurface drainage system that serves 600 acres, per acre of land in
higher valued, marketable crops

Proportion of Area in Halophytes (%)	Scenario A	Scenario B	Scenario C
		(\$/acre)	
0	41	45	51
1	41	46	51
2	41	46	52
4	42	47	53
Notes:			
Scenario A:	No Salt-Tolerant Crops or Forages		
Scenario B:	10% of Land in Salt-Tolerant Crops or Forages		
Scenario C:	20% of Land in Salt-Tolerant Crops or Forages		

Table 8-7. The estimated annual cost of owning, operating, and maintaining an IFDM system, per acre of irrigated land, including the estimated cost of the subsurface drainage system

The Solar Evaporator		Scenario A No Salt-Tolerant Crops or Forages				Scenario B: 10% of Land in Salt-Tolerant Crops or Forages				Scenario C: 20% of Land in Salt-Tolerant Crops or Forages			
Proportion of Area	Number of Acres	Proportion of Area in Halophytes (%)				Proportion of Area in Halophytes (%)				Proportion of Area in Halophytes (%)			
		0	1	2	4	0	1	2	4	0	1	2	4
(% of area)	(acres)	(\$/acre)				(\$/acre)				(\$/acre)			
0.5	3	101	104	107	114	169	174	178	187	255	261	267	279
1.0	6	103	106	109	116	172	176	180	189	258	263	269	282
1.5	9	105	108	112	118	174	178	183	192	260	266	272	284
2.0	12	108	111	114	120	177	181	185	194	263	269	275	287
Assumptions used in creating this table													
<p>The irrigated, agricultural area considered in this example is: 600 acres.</p> <p>The proportions of irrigated area in salt-tolerant forages are:</p> <p>Scenario A: 0 percent.</p> <p>Scenario B: 10 percent.</p> <p>Scenario C: 20 percent.</p>													

Table 8-8.

The estimated average annual cost of owning, operating, and maintaining an IFDM system to support irrigated production on 600 acres of land

Proportion of Area in Evaporator (%)	Land Rental Rate or Opportunity Cost (\$/acre)		
	150	100	50
	Average Cost (\$/Acre)	Average Cost (\$/Acre)	Average Cost (\$/Acre)
No production of salt-tolerant crops, forages, or halophytes			
0.5	101	101	101
1.0	103	103	102
1.5	105	105	104
2.0	108	107	106
10% of irrigated land in production of salt-tolerant crops or forages, and 2% of land in production of halophytes			
0.5	178	171	164
1.0	180	173	166
1.5	183	175	167
2.0	185	177	169
20% of irrigated land in production of salt-tolerant crops or forages, and 4% of land in production of halophytes			
0.5	279	263	247
1.0	282	265	249
1.5	284	268	251
2.0	287	270	253

Table 8-9.

Estimated costs of production for selected crops in the San Joaquin Valley and the estimated costs of installing and operating an IFDM system, in dollars per acre, per year

Cost Category	Alfalfa 2003	Acala Cotton 2003	Processing Tomatoes 2001	DOV Raisins 2003	Almonds 2003	Pistachios 2000
Estimated Costs of Crop Production						
Total Operating Costs	494	730	1,203	1,127	2,148	1,333
Cash Overhead Costs	77	167	223	262	191	326
Total Cash Costs	571	897	1,427	1,389	2,339	1,660
Non-Cash Overhead Costs	400	104	97	1,191	738	1,177
Total Costs	971	1,001	1,523	2,580	3,077	2,837
Total Revenue	972	1,063	1,925	2,550	2,860	1,975
Net Returns Above Operating Costs	478	333	722	1,423	712	642
Net Returns Above Cash Costs	401	166	498	1,161	521	316
Net Returns Above Total Costs	1	62	402	-30	-217	-861
Estimated Costs of an IFDM System						
Operating Costs	111	111	111	111	111	111
Cash Overhead Costs	3	3	3	3	3	3
Total Cash Costs	114	114	114	114	114	114
Non-Cash Overhead Costs	62	62	62	62	62	62
Total Cost of the IFDM System	176	176	176	176	176	176
Adjusted Net Returns						
Net Returns Above Operating Costs	367	222	611	1,312	601	531
Net Returns Above Cash Costs	287	51	384	1,047	407	201
Net Returns Above Total Costs	-175	-115	226	-206	-393	-1,037
Notes:						
These costs pertain to an IFDM system in which 10% of the irrigated land is used to produce salt-tolerant crops and forages, 1% of the irrigated land is used to produce halophytes, and the size of the solar evaporator is 1% of the size of the irrigated land.						
The adjusted net returns reflect the subtraction of costs pertaining to the IFDM system.						
Sources:						
The estimated costs of production are from the following sources: Alfalfa: Vargas et al., 2003; Acala Cotton: Hutmacher et al., 2003; Processing Tomatoes: May et al., 2001; DOV Raisins: Vasquez et al., 2003; Almonds: Freeman et al., 2003; Pistachios: Kallsen et al., 2000. DOV denotes Dried-on-Vine Raisins.						
The estimated costs for processing tomatoes and pistachios have been adjusted to represent costs in 2003 using the Consumer Price Index for all Urban Consumers.						

Table 8-10.

Cash and non-cash components of the estimated average annual cost of an IFDM system

Cost Category	Subsurface Drainage System (\$/acre)	Solar Evaporator (\$/acre)	Salt-tolerant Crops and Forages (\$/acre)	Halophytes (\$/acre)	System Manager (\$/acre)	Total Costs (\$/acre)
Operating Costs	5.62	1.35	38.09	0.28	65.54	110.88
Non-Cash Operating Costs		0.28	2.81	0.28		3.37
Non-Cash Overhead	39.98	3.23	16.85	1.69		61.75
Total Costs	45.60	4.86	57.75	2.25	65.54	176.00
Notes:						
These costs pertain to an IFDM system in which 10% of the irrigated land is used to produce salt-tolerant crops and forages, 1% of the irrigated land is used to produce halophytes, and the size of the solar evaporator is 1% of the size of the irrigated land.						